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Experiments with Growing Corn and Soybeans in Combination

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EXPERIMENTS WITH GROWING CORN AND SOYBEANS IN COMBINATION

H. L. BORST AND J. B. PARK

The practice of planting soybeans with corn for silage and for hogging down is extensive over the corn belt, although the indications are that the practice is not increasing at present. In Ohio the acreage of the two crops grown together and the interest in the combination have seemed sufficient to warrant careful studies regarding it.

PREVIOUS WORK

Noll and Lewis (4) of the Pennsylvania Station report 6 years' work with the combination for silage. Corn was planted at one rate, the spacing (actual stands) varying from 13 to 19 inches in different years. The soybeans were planted at three rates; namely, two, three, and four soybean seeds to one of corn. The stands of soybeans in some years were decidedly below that desired. Two rates of soybeans, three and four seeds to one of corn, gave increases over corn alone, too small, however, to be considered significant by the authors.

Kinney and Roberts (3), at the Kentucky Station, report 3 years' work with the combination; the yields were measured in mature grain. The soybeans were drilled with checked corn or planted in the hills of checked corn. With each method of planting, the soybeans reduced the yield of corn. The combined yield of soybeans and corn did not equal that of corn alone.

Etheridge and Helm (1), Missouri, reported that soybeans with drilled corn produced larger total yields of grain than soybeans in checked corn. In a 3-year experiment two stalks of soybeans and three stalks of corn to 44 inches of row or two stalks of soybeans and two stalks of corn in the same distance produced greater yields of grain than corn alone. Planting the soybeans at three stalks to 44 inches of row (corn at the same two rates) produced less total yields than corn alone. The best combinations were considered more valuable than corn alone when hogged off.

Slate and Brown (6), of Connecticut, report 3 years' work with corn both checked and drilled, one rate each, with soybeans at five rates. The combination of one stalk of corn and three of soybeans

produced an increase of about 500 pounds of dry matter and about 120 pounds of protein per acre in silage over that produced by corn alone. A larger yield was obtained from the combination when the corn was drilled rather than checked.

Odland (5) of the West Virginia Station reports 5 years' work with soybeans planted at two rates in corn at one rate. No significant increase in air-dry forage or grain or total digestible nutrients was obtained in either combination as compared with corn alone. The protein yield of the combination was slightly greater than that of corn alone when the soybeans were planted at the heavier rate.

Hughes (2), at the Iowa Station, found that, even under the most favorable conditions, corn and soybeans produced only 91.8 per cent of the grain yield of corn alone. Drilling was more favorable to the combination than checking. When harvested as forage the mixture produced a small increase over corn alone.

In the experiments mentioned above an effort was made to study the effect of different rates of planting on the productiveness of the mixture. In other experiments not discussed here the rate of planting was varied little or none.

After 3 years' preliminary work with the principal experiment reported herein, it became apparent that a critical test of the value of the combination could be obtained only by the use of varied rates of planting of both crops in order to find the rates which gave the highest yield of the combination and of corn alone. Results have justified the decision to conduct the test in that manner. It was also thought that the variety of soybeans in the combination was a factor to be considered.

Three projects have been conducted at Columbus with particular attention to rates of planting and varieties of soybeans. These experiments are designated as I, II, and III. Experiment I is a comparison of soybean varieties grown with corn. Experiment II is a plot yield test of various rates of planting corn and soybeans together. Experiment III is a field scale test of corn and soybeans grown together, planted at a rate favorable for the mixture and handled by practical farm methods. All experiments have been conducted on soils varying from the light-colored Miami silt loam and silty clay loam to the dark-colored Brookston and Clyde silty clay loams or similar types. Each year each experiment was located on a single soil type or two closely related types.

EXPERIMENT I—A COMPARISON OF SOYBEAN VARIETIES WITH CORN FOR SILAGE

This experiment was conducted from 1920 to 1924, inclusive. Duplicate tests were made each year on each of two soil types—Miami silt loam and Brookston silty clay loam. This was done to ascertain whether there is a difference in the comparative growth of corn and soybeans on soils of different fertility.

The plots consisted of two adjacent rows 3½ feet apart, about 75 feet long, and replicated once. Both corn and soybeans were carefully spaced. The corn spacing varied from 12 to 15 inches in the various years; the soybean spacing from 2 to 5 inches. Good stands of both crops were obtained in each year, except in 1921, with Midwest and Medium Green soybeans.

The plots were harvested with a corn binder set to cut as low as possible. The bundles of corn and beans from each plot were weighed intact promptly after cutting. They were then opened and the soybeans removed and weighed separately. Samples of corn and of soybeans were saved for air-dry weight determinations.

DATA AND DISCUSSION

The percentages of the different varieties of soybeans in the mixture of corn and soybeans for 5 years are given in Table 1. Four-year averages of acre yields of corn and soybeans (air-dry basis) and the average percentages of soybeans in the mixture are given in Table 2. Although the experimental error is no doubt rather high, the data are fairly consistent and represent the results of harvesting under field conditions. It will be noted from a study of the tables: (1) That the different varieties of soybeans produced varying percentages of soybeans in the crop mixture, Table 1; (2) that there was an indication that the soybean varieties which produced a high percentage of soybeans in the mixture reduced the yields of corn more than other varieties; (3) that higher total yields of mixed forage resulted where the soybeans producing the high percentages of the crop were used, Table 2.

TABLE 1.—Percentages of Varieties of Soybeans in Combination Crops of Corn and Soybeans Harvested at the Silage Stage with Corn Binder. Air-dry Basis

Variety	1920		1921		1922		1923		1924		Average 5 years		
	Light* soil	Dark† soil	Light soil	Dark soil	Light soil	Dark soil	Light soil	Dark soil	Light soil	Dark soil	Light soil	Dark soil	Average on 2 soils
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Virginia	25	10	27	31	26	27	17	9	26	20	24	19	21.5
Arlington	18	12	21	28	25	17	13	12	26	25	20	19	19.5
Peking	22	18	23	23	34	15	13	13	23	20	23	18	20.5
Wilson	14	6	23	19	24	13	11	11	23	19	19	13	16.0
Midwest	9	5	14	10	21	17	10	6	12	20	13	11	12.0
Medium Green	4	2	13	13	21	12	9	3	12	16	12	9	10.5
Hamilton	16	3	13	12	25	13	6	2	22	16	16	9	12.5
Manchu	12	3	17	19	19	12	10	2	9	11	13	9	10.5
Ito San	3	4	11	—5	17	5	5	2	12	8	10	5	7.5

*Light soil—Miami silt and silty clay loam.
†Dark soil—Brookston silty clay loam.

TABLE 2.—Acre Yields of Forage and Percentages of Soybeans in Forage from Different Varieties of Soybeans Planted with Corn

Experiment I, 4-year average—Air-dry weights

Varieties	On light-colored soil—Miami				On dark-colored soil—Brookston			
	Corn	Soybeans	Total forage	Soybeans in forage	Corn	Soybeans	Total forage	Soybeans in forage
	Lb.	*Lb.*	*Lb.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*	*Pct.*
Virginia	4,960	1,490	6,450	23	6,040	1,660	7,700	22
Arlington	5,160	1,310	6,470	20	6,510	1,530	8,040	19
Peking	4,980	1,420	6,400	22	6,860	1,410	8,270	17
Wilson	5,200	1,220	6,420	19	6,810	1,160	7,970	15
Midwest	5,150	850	6,000	14	6,660	960	7,620	13
Medium Green	5,280	810	6,090	13	7,180	800	7,980	10
Hamilton	5,140	950	6,090	16	6,750	700	7,450	9
Manchu	5,250	840	6,090	14	6,600	740	7,340	10
Ito San	5,200	660	5,860	11	6,670	350	7,020	5

It appeared that the yields of varieties varied, largely because of habit of growth and maturity. Manchu in 2 years and Ito San in 3 years of the 5 matured sufficiently to lose some leaves. Virginia and Arlington had a slightly twining habit and Peking a fairly erect habit; these two habits may have resulted in a greater proportion of total growth being harvested than of the other varieties in the experiment. Virginia, Arlington, and Peking appear to be the best varieties for growing in corn. Peking and Virginia were the most consistent. Peking was the most erect and, for that reason, is considered the superior variety.

It should be noted that the percentages of soybeans in the crops harvested were slightly but consistently greater on the soil of low fertility (Miami) than on the richer soil (Brookston). This supports the common observation that soybeans do relatively better than corn on poor soil. However, the soybeans were more erect on the poorer soil which resulted in more of the soybean plants being harvested by the corn binder.

EXPERIMENT II—SOYBEANS AND CORN PLANTED TOGETHER FOR SILAGE AND GRAIN AT DIFFERENT RATES

The experiment was started in 1919 with both checked and drilled corn. Because the results of this year (See Table 3) and previous work at Wooster reported by L. E. Thatcher (7) indicated that drilling was the more favorable method of planting corn for the combination, the checked corn was omitted after 1919. In 1920 and 1921 the experiment was in a state of transition to the plan used in 1922 and thereafter. In 1922 the plan of the experiment

TABLE 3.—Acre Yields of Corn and Soybeans Grown Together
1919

Combination	Planted May 29			Planted June 10	
	Forage		Grain	Forage	Grain
	Green	Air-dry		Green	
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Corn alone drilled 12 inches	11,547	7,050	58.7	14,552	48.4
Corn, 12 inches	17,146	8,151	53.4	15,885	45.0
Soybeans, 6 inches			7.4		5.9
Corn alone, 42 inches x 42 inches	9,380	5,758	54.0	11,144	42.8
Corn, 42 inches x 42 inches	8,860	5,971	54.7	11,773	42.5
Two soybeans per hill			1.1		1.4
Soybeans alone	16,952	5,986	23.9	11,232	21.5

was as follows: Three rates of corn and three of soybeans were used. The desired and actual average spacing of plants are given in the following tabulation:

	Corn		Soybeans	
	Spacing—Inches		Spacing—Inches	
	Desired	*Obtained*	*Desired*	*Obtained*
Thick	7 to 8	9.3	2 to 2½	3.3
Medium	14	14.9	4 to 5	5.4
Thin	22	21.5	9	12.9

Counts of the stand taken in 5 years indicate that the stand obtained was fairly close to that desired except in the thin rate of soybeans.

The calculated amounts of seed of the two varieties of soybeans needed to secure the desired stands are as follows:

	Pounds of seed per acre	
	Manchu	Peking
Thick rate, seeds spaced 2½ inches	21	9
Medium rate, seeds spaced 4–5 inches	12	5
Thin rate, seeds spaced 9 inches	6	2½

The various combinations of the above rates are given in Tables 4 to 8.

After 1921, the corn was spaced by actual measurement. The medium and thin rates were planted at two or three kernels in a place and thinned to one stalk. The thick rate was planted one kernel in a place and not thinned. The thick and medium soybeans were planted with an accurate hand drill calibrated to plant at the desired spacing. The thin rate was planted by hand.

The plots consisted of four rows, grown usually in three replications. When plots planted at different rates were adjacent they were separated by buffer rows. One-half of each plot, where beans were included, was planted to Peking to be harvested with the corn at the silage stage, and one-half to Manchu to be harvested when mature.

The harvesting was done by hand, care being exercised to save all of the soybeans. The half of each plot planted with Peking soybeans was harvested when the corn had reached the silage stage; that is, ears well dented and hard, plants green except lowest leaves. Green weights were taken in the field. Air-dry weights were determined from samples dried inside a building, usually the laboratory.

The plants on the half of each plot planted with Manchu soybeans were allowed to mature. The soybeans were cut and threshed, and the corn was husked from the standing stalks. Samples of corn were taken for the determination of moisture and shelling percentages.

DATA AND DISCUSSION

COMPETITION BETWEEN CORN AND SOYBEANS WHEN PLANTED TOGETHER

The reductions in yield of corn forage in the combination caused by the soybeans, compared to corn alone, are shown graphically in Figures 1 and 2 and in percentages in the following tabulation:

	Forage*—Air-dry			Grain*—15 per cent moisture		
	Soybeans thick	Soybeans medium	Soybeans thin	Soybeans thick	Soybeans medium	Soybeans thin
Corn thick	17	11	7	21	15	6
Corn medium	20	19	12	20	18	8
Corn thin	23	.....	8	23	.....	8

*8-year average.

At all three rates of planting corn, the yields of corn were reduced progressively as the rate of planting soybeans increased.

As the rate of planting corn was lowered, the reduction in yield of corn caused by the soybeans became greater. Thus, the thinner planted corn suffered a greater loss in yield from competition with the soybeans than did the thicker planted corn. However, the expected amount of reduction in yield of corn did not occur when both corn and soybeans were planted at the thin rates. Apparently,

in this case the land was not fully utilized by the plants and competition was not as intense. Similar trends are shown by the grain yields.

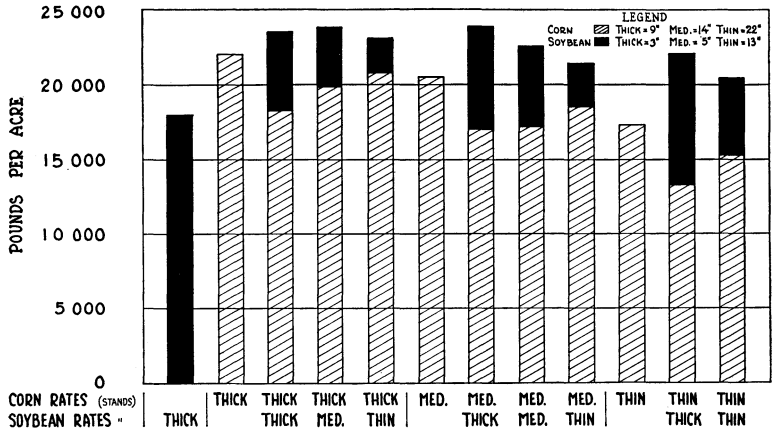

Fig. 1.—Yields of corn and soybeans grown together—Forage yields
Green weights. 8-year average

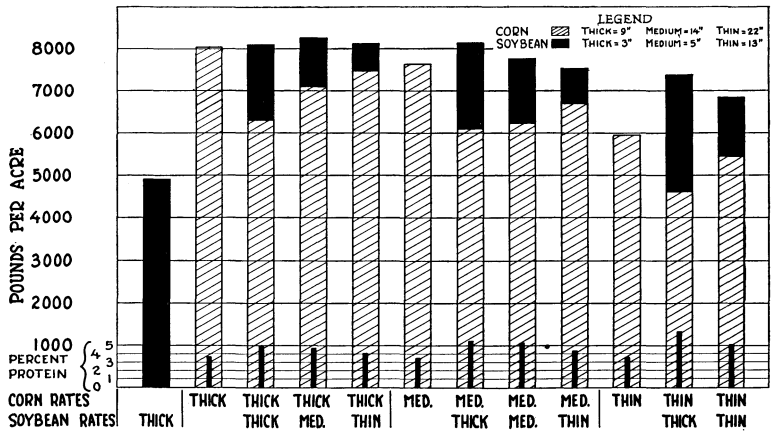

Fig. 2.—Yields of corn and soybeans grown together—Forage yields
Air-dry. 8-year average

ACRE YIELDS AT THE SILAGE STAGE

Green weight yields of the crop at the silage stage are given in Table 4.

TABLE 4.—Acre Yields of Forage from Corn and Soybeans Grown Together

Green Weight—Experiment II

Combination and rate*	1919		1920		1921		1922		1923		1924		1925	
	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1. Soybeans alone	16,950	16,950	21,210	21,210	18,570	18,570	23,040	23,040	19,850	19,850	9,840	9,840	16,710	16,710
2. Corn thick, alone							15,290	15,290	24,180	24,180	15,750	15,750	27,890	27,890
3. Corn thick							14,020	20,090	18,070	22,410	10,150	14,680	22,820	26,660
Soybeans thick							6,070		4,340		4,530		3,840	
4. Corn thick							14,560	20,480	19,870	22,930	12,280	15,340	24,090	26,380
Soybeans medium							5,920		3,060		3,060		2,290	
5. Corn thick							15,330	18,040	20,770	22,680	13,450	15,030	25,360	26,830
Soybeans thin							2,710		1,910		1,580		1,470	
6. Corn medium, alone	11,550	11,550	21,560	21,560	16,480	16,480	15,760	15,760	19,400	19,400	14,250	14,250	27,400	27,400
7. Corn medium							11,950	22,340	17,930	24,260	10,890	15,180	22,330	26,790
Soybeans thick							10,390		6,330		4,290		4,460	
8. Corn medium	11,440	17,150	24,050	28,460	15,490	22,240	13,070	22,800	17,630	22,410	10,320	13,400	23,230	26,500
Soybeans medium	5,710		4,410		6,750		9,730		4,780		3,080		3,270	
9. Corn medium							14,630	19,480	18,280	20,930	11,760	13,180	23,760	25,600
Soybeans thin							4,850		2,650		1,420		1,840	
10. Corn thin, alone													21,680	21,680
11. Corn thin							10,590	22,320	16,540	21,210	7,590	13,080	15,460	23,230
Soybeans thick							11,730		4,670		5,490		7,770	
12. Corn thin							12,480	20,190	14,790	24,780	9,930	12,580	18,160	21,760
Soybeans thin							7,710		9,990		2,650		3,600	

TABLE 4.—Acre Yields of Forage from Corn and Soybeans Grown Together—Continued

Green Weight—Experiment II

Combination and rate*	1926		1927		1928		1929		8-year average		11-year average	
	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1. Soybeans alone.....	18,610	18,610	17,170	17,170	19,090	19,090	19,990	19,990	18,030	18,030	18,280	18,280
2. Corn thick, alone.....	21,610	21,610	22,420	22,420	21,110	21,110	28,170	28,170	22,050	22,050	.....	.....
3. Corn thick.....	20,200	25,110	19,850	26,350	18,590	24,120	23,990	29,220	18,460	23,580	.....	.....
Soybeans thick.....	4,910		6,500		5,530		5,230		5,120		.....	.....
4. Corn thick.....	20,470	24,970	21,950	27,620	19,850	22,930	26,030	30,160	19,890	23,850	.....	.....
Soybeans medium....	4,500		5,670		3,080		4,130		3,960		.....	.....
5. Corn thick.....	20,820	23,140	22,700	25,020	21,010	23,350	27,600	29,980	20,880	23,010	.....	.....
Soybeans thin.....	2,320		2,320		2,340		2,380		2,130		.....	.....
6. Corn medium, alone..	20,440	20,440	22,310	22,310	20,370	20,370	24,840	24,840	20,600	20,600	19,490	19,490
7. Corn medium.....	17,410	24,370	19,080	26,380	16,680	24,630	20,810	27,030	17,130	23,870	.....	.....
Soybeans thick.....	6,960		7,300		7,950		6,220		6,740		.....	.....
8. Corn medium.....	18,260	24,480	18,640	25,140	16,290	20,740	20,760	25,940	17,270	22,670	17,200	22,660
Soybeans medium....	6,220		6,500		4,450		5,180		5,400		5,460	
9. Corn medium.....	19,080	22,960	20,240	23,750	17,180	19,600	23,990	26,080	18,620	21,450	.....	.....
Soybeans thin.....	3,880		3,510		2,420		2,090		2,830		.....	.....
10. Corn thin, alone.....	17,380	17,380	19,440	19,440	16,150	16,150	20,570	20,570	17,340	17,340†	.....	.....
11. Corn thin.....	11,650	21,830	16,310	26,730	11,840	21,360	16,290	26,690	13,280	22,050	.....	.....
Soybeans thick.....	10,180		10,420		9,520		10,400		8,770		.....	.....
12. Corn thin.....	14,790	21,150	18,660	21,760	15,460	19,080	18,150	23,420	15,300	20,590	.....	.....
Soybeans thin.....	6,360		3,100		3,620		5,270		5,290		.....	.....

*

Spacing of plants, in inches:	Corn			Soybeans		
	Thick	Medium	Thin	Thick	Medium	Thin
Desired	7-8	14	22	2-2½	4-5	9
Obtained ..... (Average 5-year count)	9.3	14.9	21.5	8.3	5.4	12.9

†Computed from 5 years' data compared with 8-year average of 2 adjacent plots.

Comparing the yields of corn alone at the three rates with the yields of the various combinations, it will be noted: (1) That as an 8-year average the combination of corn thick and soybeans medium out-yields corn alone thick by about 1800 pounds green weight; (2) that the combination corn medium, soybeans thick out-yielded corn alone medium by over 3200 pounds; and (3) that the yield of corn thin and beans thick exceeded that of corn thin alone by more than 4000 pounds. The difference required to be significant, with odds of 20:1 computed by Fisher's method of analysis of variance, is 1527 pounds per acre. It would seem that on the green weight basis the increases in yield of the combination compared to corn alone are significant. Although farmers are prone to think of yields of silage in terms of green weight, dry matter furnishes a better basis for comparison, and the yield of total digestible nutrients is no doubt the best.

Air-dry weights (laboratory dry, about 10 per cent moisture) are used in Table 5 and Figure 2 as the basis for dry-weight comparisons. The rather large increase in yield of the mixture over corn alone on the green weight basis largely disappears when they are compared on the air-dry basis. This is explained by a higher moisture content in the soybeans than in the corn, at the green stage, which increased the moisture content of the mixture. As an 8-year average, the corn in the mixture contained about 64 per cent moisture, and the soybeans, about 71 per cent.

Another reason for the difference in results between the green silage and the air-dry basis of comparison is that in some years corn alone was somewhat earlier and had a higher percentage of dry matter at harvest time than the corn growing with soybeans.

Calculations made in the same way as for green weights show that for odds of 20:1 a difference of less than 446 pounds air-dry weight is not significant. It appears, therefore, that on an air-dry basis the increase of 230 pounds in yield of the combination corn thick, soybeans medium over that of corn thick alone is not significant. The 500 pounds increase of corn medium, soybeans thick over corn medium alone may possibly be significant. The increased yield (1390 pounds) of corn thin and soybeans thick over corn alone thin is doubtless significant.

TABLE 5.—Acre Yields of Forage from Corn and Soybeans Grown Together

Air-dry Weights—Experiment II

Combination and rate*	1919		1920		1921		1922		1923		1924		1925	
	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1. Soybeans alone	5,990	5,990	5,990	5,990	4,780	4,780	6,210	6,210	7,490	7,490	2,960	2,960	4,530	4,530
2. Corn thick, alone							8,260	8,260	9,510	9,510	5,320	5,320	9,330	9,330
3. Corn thick							6,810		6,550		3,280		8,260	
Soybeans thick							2,020	8,830	1,620	8,170	1,240	4,520	1,030	9,290
4. Corn thick							7,080		7,210		3,970		8,710	
Soybeans medium							1,960	9,040	1,140	8,350	920	4,890	620	9,330
5. Corn thick							7,440		7,540		4,350		9,160	
Soybeans thin							900	8,340	720	8,260	480	4,830	400	9,560
6. Corn medium, alone	7,050	7,050	8,620	8,620	5,280	5,280	8,740	8,740	7,610	7,610	5,010	5,010	9,840	9,840
7. Corn medium							5,800		6,500		3,650		8,080	
Soybeans thick							3,450	9,250	2,380	8,880	1,320	4,970	1,320	9,400
8. Corn medium	6,350		9,550		5,020		6,350		6,390		3,460		8,410	
Soybeans medium	1,800	8,150	1,220	10,770	1,880	6,900	3,210	9,560	1,770	8,160	960	4,420	970	9,380
9. Corn medium							7,110		6,620		3,940		8,590	
Soybeans thin							1,610	8,720	980	7,600	440	4,380	540	9,130
10. Corn thin, alone													6,500	6,500
11. Corn thin							5,150		5,370		2,530		4,870	
Soybeans thick							3,890	9,040	3,770	9,140	1,740	4, 270	2,130	7,000
12. Corn thin							6,060		6,010		3,320		5,730	
Soybeans thin							2,560	8,620	1,770	7,780	840	4,160	990	6,720

TABLE 5.—Acre Yields of Forage from Corn and Soybeans Grown Together—Continued

Air-dry Weights—Experiment II

Combination and rate*	1926		1927		1928		1929		8-year average		11-year average	
	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total	Each	Total
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1. Soybeans alone	4,320	4,320	3,590	3,590	5,350	5,350	4,800	4,800	4,910	4,910	5,090	5,090
2. Corn thick, alone	7,050	7,050	7,330	7,330	8,420	8,420	9,010	9,010	8,030	8,030	.....	.....
3. Corn thick	6,580	7,720	6,490	7,850	7,420	9,320	7,680	9,040	6,630	8,090	.....	.....
Soybeans thick	1,140		1,360		1,900		1,360		1,460		.....	.....
4. Corn thick	6,670	7,720	7,180	8,370	7,920	8,980	8,330	9,410	7,130	8,260	.....	.....
Soybeans medium	1,050		1,190		1,060		1,080		1,130		.....	.....
5. Corn thick	6,790	7,330	7,420	7,910	8,380	9,180	8,830	9,450	7,490	8,110	.....	.....
Soybeans thin	540		490		800		620		620		.....	.....
6. Corn medium, alone	6,660	6,660	7,300	7,300	8,130	8,130	7,950	7,950	7,650	7,650	7,470	7,470
7. Corn medium	5,680	7,290	6,240	7,770	6,660	9,390	6,660	8,280	6,160	8,150	.....	.....
Soybeans thick	1,610		1,530		2,730		1,620		1,990		.....	.....
8. Corn medium	5,950	7,390	6,090	7,450	6,500	8,030	6,640	7,990	6,220	7,790	6,430	8,020
Soybeans medium	1,440		1,360		1,530		1,350		1,570		1,590	
9. Corn medium	6,220	7,120	6,620	7,350	6,860	7,690	7,680	8,220	6,700	7,520	.....	.....
Soybeans thin	900		730		830		540		820		.....	.....
10. Corn thin, alone	5,670	5,670	6,360	6,360	6,440	6,440	6,580	6,580	5,990	5,990†	.....	.....
11. Corn thin	3,800	6,160	5,340	7,520	4,720	7,990	5,210	7,920	4,620	7,380	.....	.....
Soybeans thick	2,360		2,180		3,270		2,710		2,760		.....	.....
12. Corn thin	4,820	6,300	6,100	6,750	6,170	7,410	5,810	7,180	5,500	6,860	.....	.....
Soybeans thin	1,480		650		1,240		1,370		1,360		.....	.....

*

Spacing of plants, in inches:	Corn			Soybeans		
	Thick	Medium	Thin	Thick	Medium	Thin
Desired	7-8	14	22	2-2½	4-5	9
Obtained (Average 5-year count)	9.3	14.9	21.5	3.3	5.4	12.9

†Computed from 5 years' data compared with 8-year average of 2 adjacent plots.

As has been previously stated, the decrease in corn yield caused by the soybeans becomes progressively less with the thicker rates of planting corn; also, the corresponding increase produced by the soybeans over corn alone becomes progressively less the thicker the rate of planting the corn. It seems that, if the rate of planting corn alone is heavy enough, the crop fully utilizes the productive power of the soil and the additional planting of soybeans does not increase the total yield of dry matter. It should be pointed out here that, if only a medium or thin rate of planting corn had been used in this experiment, the conclusion would be justified that the combination produces more silage than corn alone. It was necessary to find and use optimum rates of planting the crops both alone and in combination.

With a stand of corn that does not fully utilize the soil, growers can increase their total silage yields by planting a suitable variety of soybeans with the corn, provided the soybeans are planted sufficiently thick and that methods of harvesting are such as to insure getting the soybeans. The question of the advisability of planting soybeans with corn for silage depends, then, largely upon the total digestible nutrients produced by the combination and the percentage of protein in the mixture.

TOTAL DIGESTIBLE NUTRIENTS AND PROTEIN IN CORN AND SOYBEANS AT THE SILAGE STAGE

Data on total digestible nutrients and protein, calculated from analyses reported by Henry and Morrison (revised edition), are given in Table 6 and are shown graphically in Figure 3. Yields of total digestible nutrients from the three combinations of thick corn with soybeans are not significantly higher than from thick corn alone. However, the combination corn medium, beans thick exceeded corn alone medium by nearly 200 pounds of total digestible nutrients. But this combination is out-yielded in total digestible nutrients by corn alone at the thick rate. Apparently, the virtue of the combination of the two crops, if it has any, lies in its increased protein production.

TABLE 6.—Acre Yields of Forage, Protein, and Total Digestible Nutrients and Percentage of Protein in Forage

Experiment II

Combination and rate	Forage (air-dry)		Digestible protein						Total digestible nutrients			
	8-year average		8-year average			11-year average			8-year average		11-year average	
	Each	Total	Each	Total	Protein in mixture	Each	Total	Protein in mixture	Each	Total	Each	Total
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Pct.*	*Lb.*	*Lb.*	*Pct.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1. Soybeans alone	4,905	4,905	574	574	11.70	596	596	11.7	2,629	2,629	2,728	2,728
2. Corn alone, thick	8,030	8,030	281	281	3.50	.....	.....	.....	4,706	4,706	.....	.....
3. Corn thick	6,634	8,092	232	403	4.98	.....	.....	.....	3,888	4,669	.....	.....
Soybeans thick	1,458		171			.....	.....	.....	781		.....	.....
4. Corn thick	7,134	8,260	250	382	4.62	.....	.....	.....	4,181	4,785	.....	.....
Soybeans medium	1,126		132			.....	.....	.....	604		.....	.....
5. Corn thick	7,489	8,107	262	334	4.12	.....	.....	.....	4,389	4,720	.....	.....
Soybeans thin	618		72			.....	.....	.....	331		.....	.....
6. Corn alone, medium	7,653	7,653	268	268	3.50	261	261	3.5	4,485	4,485	4,377	4,377
7. Corn medium	6,158	8,151	216	449	5.51	.....	.....	.....	3,609	4,677	.....	.....
Soybeans thick	1,993		233			.....	.....	.....	1,068		.....	.....
8. Corn medium	6,223	7,797	218	402	5.16	225	411	5.13	3,647	4,491	3,766	4,619
Soybeans medium	1,574		184			186			844		853	
9. Corn medium	6,703	7,525	235	331	4.40	.....	.....	.....	3,928	4,369	.....	.....
Soybeans thin	822		96			.....	.....	.....	441		.....	.....
10. Corn alone, thin	5,988*	5,988	210	210	3.50	.....	.....	.....	3,509	3,509	.....	.....
11. Corn thin	4,624	7,379	162	484	6.56	.....	.....	.....	2,710	4,187	.....	.....
Soybeans thick	2,755		322			.....	.....	.....	1,477		.....	.....
12. Corn thin	5,502	6,863	193	352	5.13	.....	.....	.....	3,224	3,953	.....	.....
Soybeans thin	1,361		159			.....	.....	.....	729		.....	.....

*Calculated 8-year average.

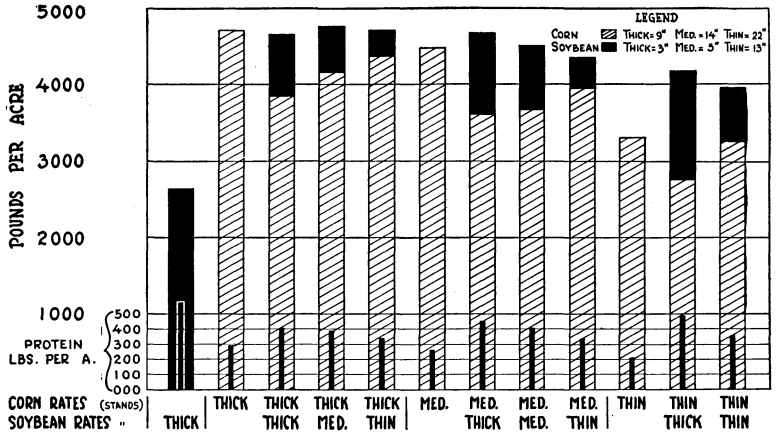

Fig. 3.—Total digestible nutrients in forage
8-year average

The mixture from the highest yielding combination (corn thick, soybeans medium) contained a little over 1 per cent more protein (air-dry basis) than did corn alone planted at the same rate. The increase in yield of protein was about 100 pounds per acre. The product from the next best combination (corn medium, soybeans thick) contained about 2 per cent more protein than corn alone at the same rate. The increased yield of protein here was about 180 pounds per acre over corn alone at the medium rate.

On an acre basis these increases in protein yield might seem worth while. One hundred pounds of protein are nearly the equivalent of 250 pounds of cottonseed meal containing 40 per cent protein. It should be noted, however, that this protein was carried in about 9 tons of silage. The part of this additional protein consumed by a dairy cow in a daily ration of 30 pounds of silage would be of negligible value.

CONCLUSIONS FROM EXPERIMENT II—SILAGE

1. The rate of planting is important as that factor may determine the productiveness of the mixture as compared to corn alone.

2. Yields of silage from corn versus corn and soybeans should not be compared on the green-weight basis since the soybeans are likely to have a different moisture content from the corn. For this reason an apparent increase in yield of the mixture on the green basis may not be a real increase.

TABLE 7.—Acre Yields of Grain from Corn and Soybeans Grown Together‡

Experiment II

Combination and rates*	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	7-year average		10-year average	
	Each	Each	Each	Each	Each	Each	Each	Each	Each	Each	Each	Total	Each	Total
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1. Soybeans alone	1,435	1,212	1,372	1,596	1,642	751	954	1,380	996	927	1,178	1,178	1,226	1,226
2. Corn alone, thick	.....	.....	.....	1,800	3,667	1,320	3,830	4,116	3,186	2,464	2,912	2,912	.....	.....
3. Corn thick	.....	.....	.....	1,360	2,127	797	3,349	3,713	2,615	2,117	2,297	2,633	.....	.....
Soybeans thick	.....	.....	.....	397	401	272	120	294	420	449	336		.....	.....
4. Corn thick	.....	.....	.....	1,470	2,388	916	3,377	3,774	3,058	2,419	2,486	2,742	.....	.....
Soybeans medium	.....	.....	.....	370	347	221	96	216	354	186	256		.....	.....
5. Corn thick	.....	.....	.....	1,655	2,569	1,166	3,651	3,870	3,360	2,800	2,724	2,850	.....	.....
Soybeans thin	.....	.....	.....	135	158	71	48	120	168	184	126		.....	.....
6. Corn alone, medium	3,288	4,615	2,102	1,945	3,632	1,588	4,004	4,010	3,808	3,086	3,153	3,153	3,208	3,208
7. Corn medium	.....	.....	.....	1,565	2,417	898	3,405	3,618	3,304	2,358	2,509	2,898	.....	.....
Soybeans thick	.....	.....	.....	566	608	245	192	372	444	296	389		.....	.....
8. Corn medium	2,992	4,643	1,351	1,604	2,573	958	3,539	3,578	3,478	2,318	2,578	2,933	2,703	3,103
Soybeans medium	446	410	656	630	456	221	168	378	378	253	355		400	
9. Corn medium	.....	.....	.....	1,909	3,531	1,160	3,556	3,769	3,763	2,688	2,911	3,101	.....	.....
Soybeans thin	.....	.....	.....	265	191	101	84	210	234	244	190		.....	.....
10. Corn alone, thin	.....	.....	.....	.....	.....	.....	3,270	3,556	3,472	2,279	2,658†	2,658†	.....	.....
11. Corn thin	.....	.....	.....	1,451	2,545	660	2,519	2,755	2,582	1,848	2,051	2,691	.....	.....
Soybeans thick	.....	.....	.....	926	874	415	372	606	588	700	640		.....	.....
12. Corn thin	.....	.....	.....	1,592	2,831	1,314	2,814	3,091	3,164	2,335	2,449	2,771	.....	.....
Soybeans thin	.....	.....	.....	529	418	163	156	324	300	366	322		.....	.....

*

Spacing of plants, in inches:	Corn			Soybeans		
	Thick	Medium	Thin	Thick	Medium	Thin
Desired	7-8	14	22	2-2½	4-5	9
Obtained (Average 5-year count)	9.3	14.9	21.5	3.3	5.4	12.9

†Computed from 4 years' data compared with 7-year average of 2 adjacnt plots.

‡Corn 15 per cent moisture, soybeans air-dry, approximately 15 per cent moisture.

3. Soybeans grown with corn always reduced the yield of corn silage as compared with corn alone, regardless of the rate of planting.

4. The thicker the corn was planted, the less was the advantage accruing from the soybeans planted with the corn.

5. In both medium and thin corn (not fully utilizing the soil), the thicker the soybeans the greater was the total yield of the combination in air-dry matter, total nutrients, and protein.

6. In thick corn which apparently utilized the full productive power of the soil, the addition of soybeans or increasing their rate of planting produced no increase in total digestible nutrients but did increase the yield of protein somewhat.

YIELDS OF GRAIN

The yields of grain are shown in Table 7. The soybean does not compete as successfully with corn in grain production as in the production of forage. The soybeans at all three rates, when planted with either medium or thick corn, failed to make up in yield of grain the decrease they caused in the yield of corn, as compared with corn alone. In thin corn where competition was less severe they made up slightly more than the loss of corn.

YIELDS AND PERCENTAGES OF TOTAL DIGESTIBLE NUTRIENTS AND PROTEIN IN GRAIN

As with forage, however, probably the best criteria of the value of the combination for grain are the yields of total digestible nutrients and of protein. Data regarding these yields are shown in Table 8 and Figure 4.

There is an important difference between the silage yields and the grain yields in regard to total digestible nutrients. In the silage experiment, increasing the rate of planting the soybeans increased the yield of total digestible nutrients; whereas, in the grain experiment, increasing the rate of planting the soybeans has decreased the yield of total digestible nutrients (See Figure 4).

As with the yields of grain, no combination of soybeans with corn at the thick rate produced as much total digestible nutrients as did corn alone at that rate. The same is true of soybeans with corn at the medium rate. The soybeans, at the two rates used (thick and thin), planted with corn at the thin rate produced greater yields of total digestible nutrients than thin corn alone. The increases were small, 110 pounds an acre for thick and 140 pounds for thin soybeans.

TABLE 8.—Acre Yields of Total Digestible Nutrients and Protein in Grain from Corn and Soybeans Grown Together

Experiment II

Combination and rate*	Grain						7-year average						10-year average					
	7-year average			10-year average			Protein			Total digestible nutrients			Protein			Total digestible nutrients		
	Corn	Soybeans	Total	Corn	Soybeans	Total	Corn	Soybeans	Total	Corn	Soybeans	Total	Corn	Soybeans	Total	Corn	Soybeans	Total
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1. Soybeans alone...	.....	1,178	1,178	.....	1,226	1,226	.....	391	391	.....	1,110	1,110	.....	407	407	.....	1,150	1,150
2. Corn alone, thick.	2,912	.....	2,912	.....	.....	.....	207	.....	207	2,380	.....	2,380	.....	.....	.....	.....	.....	.....
3. Corn thick..... Soybeans thick...	2,297	336	2,633	.....	.....	.....	163	112	275	1,880	320	2,200	.....	.....	.....	.....	.....	.....
4. Corn thick..... Soybeans medium	2,486	256	2,742	.....	.....	.....	176	85	261	2,030	240	2,270	.....	.....	.....	.....	.....	.....
5. Corn thick..... Soybeans thin....	2,724	126	2,850	.....	.....	.....	193	42	235	2,230	120	2,350	.....	.....	.....	.....	.....	.....
6. Corn alone, med..	3,153	.....	3,153	3,208	.....	3,208	224	.....	224	2,580	.....	2,580	228	.....	228	2,620	.....	2,620
7. Corn medium..... Soybeans thick...	2,509	389	2,898	.....	.....	.....	178	129	307	2,050	370	2,420	.....	.....	.....	.....	.....	.....
8. Corn medium..... Soybeans medium	2,578	355	2,933	2,703	400	3,103	183	118	301	2,110	330	2,440	192	133	325	2,210	370	2,580
9. Corn medium..... Soybeans thin....	2,911	190	3,101	.....	.....	.....	207	63	270	2,380	180	2,560	.....	.....	.....	.....	.....	.....
10. Corn alone, thin..	2,658	.....	2,658	.....	.....	.....	189	.....	189	2,170	.....	2,170	.....	.....	.....	.....	.....	.....
11. Corn thin..... Soybeans thick...	2,051	640	2,691	.....	.....	.....	146	212	358	1,680	600	2,280	.....	.....	.....	.....	.....	.....
12. Corn thin..... Soybeans thin....	2,449	322	2,771	.....	.....	.....	174	107	281	2,000	310	2,310	.....	.....	.....	.....	.....	.....

*

Spacing of plants, in inches:	Corn			Soybeans		
	Thick	Medium	Thin	Thick	Medium	Thin
Desired	7-8	14	22	2-2½	4-5	9
Obtained	9.3	14.9	21.5	3.3	5.4	12.9

(Average 5-year count)

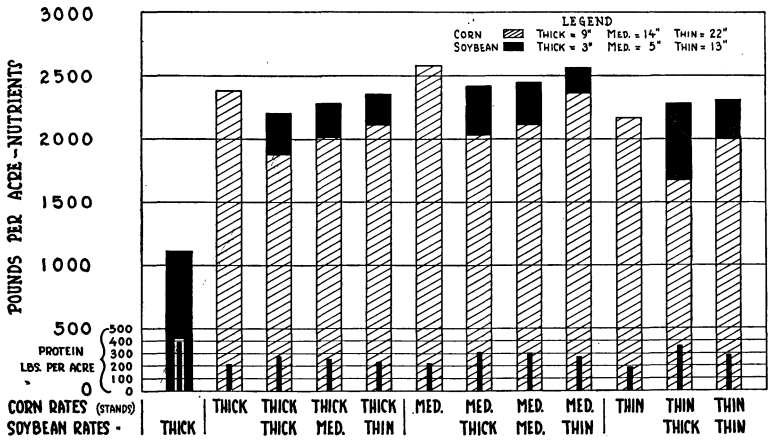

Fig. 4.—Yields of total digestible nutrients in grain
7-year average

The yield of protein from the combination, unlike that of total digestible nutrients, increased with the rate of planting the soybeans. The yield of protein also increased as the rate of planting corn decreased. Soybeans planted with corn at any of the three rates increased the acre production of protein as compared with corn alone at that rate, the greatest increase coming from the thickest rate of beans in each case. The combination producing the most protein per acre was corn thin and soybeans thick This combination produced about 169 pounds of protein more than did corn alone at the thin rate and it produced 134 pounds of protein more than medium corn alone which produced the highest yield of total digestible nutrients.

In evaluating the protein yield of the combination from a practical standpoint, the yield of protein in the combination that produced the greatest amount of total digestible nutrients should be considered. This combination was corn medium, soybeans thin. The yield of total digestible nutrients here was nearly equal to corn alone medium, and the protein yield was 36 pounds per acre greater. This is a small increase, but, since it was produced with practically no sacrifice of total digestible nutrients, it would be worth while if the added protein were actually utilized by pasturing. If the maximum acre yield of protein is desired, it can be produced by growing soybeans alone.

CONCLUSIONS FROM EXPERIMENT II—GRAIN

1. Soybeans grown with corn always reduced the yield of corn grain, as compared to corn alone, regardless of the rate of planting.

2. With thick and medium corn, the soybeans did not increase the total digestible nutrients in the mixed grain over corn alone. With thin corn, the soybeans at the two rates planted (thick and thin) increased the total nutrients slightly.

3. Increasing the rate of planting the soybeans with the corn when the corn was planted at any of the three rates decreased the yield of total nutrients in the grain mixture.

4. At each rate of planting corn the yield of protein increased with each increase in the rate of planting soybeans.

5. At any given rate of planting soybeans the yield of protein increased as the rate of planting corn decreased.

6. The combination, then, producing the most protein was corn thin, soybeans thick.

7. Corn alone medium produced the greatest yield of total digestible nutrients in the grain.

8. Planting soybeans at the thin rate with corn at the medium rate increased the protein yield of the combination about 36 pounds per acre and only slightly decreased the total digestible nutrients, as compared with corn alone.

EXPERIMENT III—CORN AND SOYBEANS IN COMBINATION UNDER FIELD CONDITIONS

In the foregoing experiments the harvesting was done by hand with the result that practically all the soybeans grown were saved. In order to determine what would happen under farm conditions, a third experiment was conducted from 1920 to 1923, inclusive.

Each year two areas of approximately one acre each were chosen in fields of Reid corn grown for silage by the University. Peking soybeans were drilled with an accurate garden drill in the rows immediately after the corn was planted. The spacing of the corn averaged 12 inches and that of the soybeans 4 to 5 inches. In 3 years of the 4 the soil used was a fertile bottom soil known as Genessee sandy clay loam.

The crop was harvested with a corn binder. The loads of green fodder were weighed at the silo. Six bundles from each load were used for determination of the percentage of soybeans in the material and of air-dry weights.

DATA AND DISCUSSION

Green and air-dry yields are reported in Table 9. In 2 years of the 4 the combination yielded less than corn alone, and in 2 years it yielded more. As an average of the 4 years the difference in favor of corn alone was about 1700 pounds green weight, or over 600 pounds dry weight.

These differences should not be regarded as significant, though there are small odds in favor of corn alone. The experiment is reported because it indicates what might be expected under similar conditions; viz., the combination grown under field conditions, on a very fertile soil with a rather rank-growing variety of corn planted at what might be called a medium rate. It would seem that the soil was the major factor determining the results obtained. On soil of high fertility the corn makes a vigorous growth, resulting in a low percentage of soybeans in the forage mixture.

Corn and soybean yields were not determined separately so that it is impossible to tell how much the soybeans reduced the yields of corn. It is evident, however, that the reduction was greater than the compensating yield of soybeans. The lower yields of the combination may be partly accounted for by the fact that many of the soybeans were lost in harvesting, some not cut and others lost from the bundles. From determinations made in 1921 these losses were found to be as follows: Soybeans produced per acre, 2500 pounds; soybeans uncut, 1000 pounds; lost from the bundles, 560 pounds.

Thirty-seven per cent of the soybeans was left in the field. This may be explained by the fact that the soybeans growing in the very tall, thick corn were weak stemmed and procumbent and, therefore, were not successfully handled by the corn binder. Moreover, the total yield of soybeans and the proportion of soybeans to corn were low as compared to the other experiments reported. The data indicate that under conditions of high fertility with a rank growth and high yield of corn, planting soybeans with the corn is of no advantage, confirming the results secured in Experiment II.

GENERAL CONCLUSIONS

THE VALUE OF THE COMBINATION FOR SILAGE

Detailed conclusions drawn from the various experiments are given on Pages 5, 18, 22, and 24. Experiments II and III indicate that, even under conditions favorable to the mixture and where most of the soybeans grown in the corn are saved, the growing of

TABLE 9.—Acre Yields of Corn and Soybean Forage from Field Test

Experiment III

Crop	1920		1921		1922		1923		Average	
	Green	Air-dry	Green	Air-dry	Green	Air-dry	Green	Air-dry	Green	Air-dry
	Lb.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Corn alone spaced 12 inches	38,200	11,650	20,320	8,570	19,000	6,970	33,150	9,270	27,670	9,115
Corn (12 inches) and soybeans (6 inches)	32,050	9,790	21,980	8,790	20,060	7,220	29,760	8,180	25,960	8,495
Difference in favor of corn alone	+6,150	+1,860	−1,660	−220	−1,060	−250	+3,390	+1,090	+1,710	+620
Percentage of soybeans in the mixture	2.82		14.8		10.5		4.9		4.6	

soybeans and corn together for silage has little to recommend it. In Experiment II a small increase in protein was obtained. Under field conditions enough soybeans might easily be lost in harvesting to offset this increase in protein.

THE VALUE OF THE COMBINATION FOR GRAIN PRODUCTION

The combination may have more practical value for hogging off than for the production of silage. A low rate of planting the soybeans is desirable for this purpose since hogs will not consume many soybeans when they have access to corn. Besides, a high percentage of soybeans in the ration produces pork with soft fat and thus reduces the market value. Soybeans planted at a low rate suitable for hogging reduce the yield of corn only slightly and increase the yield of protein. Whether the combination is practical will depend on the farm supply of protein. If the grower has no other source of protein, supplying it with soybeans in the corn to be hogged off is better than not supplying it at all.

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